collected July 9, 1947, and the first of *holopticus* July 17, 1948. The first pupae of both species were collected July 9, 1947. The last larva of *dichopticus* was collected September 7, 1948, the last of *holopticus*, August 31, 1948. The last pupae of both species were collected September 8, 1948. Larvae of this genus, too small to determine, were collected from July 2 to 30, 1948.

The pupae are found singly on the undersides of rocks in streams that are usually rather small and shallow, averaging 6 to 8 feet wide and 5 inches deep, with a range of 1.5 to 60 feet in width, and 1 to 18 inches in depth. The streams are swift, flowing from 2 to 6 feet per second and often tumbling. Stream bottoms varied greatly, ranging from a complete cover of small boulders and large rocks to scattered large gravel on mud or sand. The streams were also cold, the average temperature of all of them being 39°F. The type locality of *dichopticus* never exceeded 40°F. all through the season and that of *holopticus* only went to 47.5°. The average temperature of the streams in which *dichopticus* were found was 1° lower than that for *holopticus*, but this may not be significance since it involves a number of streams in which the temperature was taken only twice. The pH of the streams ran from 7 to 8.5 with no difference between the habitats of the two species.

MELANOPLUS RUGGLESI, A MIGRATORY GRASSHOPPER FROM THE GREAT BASIN OF NORTH AMERICA[1]

(ORTHOPTERA ACRIDIDAE)

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In the summer of 1939 there first came to the attention of contemporary entomologists an unusual infestation of grasshoppers in Big Smoky Valley, Nye County, Nevada. Since 1939 many separate bands have moved northwesterly, until by 1949 a very large area of range land was involved in northwestern Nevada, southeastern Oregon, and northeastern California. The migratory movements of the grasshopper concerned have been one of the more striking cases of insect migration in the United States. The situation is of special interest to students of grasshoppers because in this species migratory and solitary phases apparently are well demonstrated.

Gallaway (Jour. Econ. Ent. 41:925-927, 1949) gave a thorough preliminary review of the current series of infestations, and he referred the grasshopper to *Melanoplus occidentalis occidentalis* (Thomas), based at least in part on my iden-

[1]Publication costs paid by author.

tifications of some ten years ago. More recent studies have shown that true *occidentalis*, which was originally described from eastern Wyoming, is distinct from the Great Basin species, and that the latter is without a name. In order that a name may be available to economic workers prior to the completion of an illustrated and comprehensive treatment of the *occidentalis* species-group, the present description has been prepared. Full acknowledgment of the cooperation that has helped greatly in the work will be included in the later report.

Melanoplus rugglesi[2], new species

Male, migratory phase (holotype).—Size large for species-group; general form as in *occidentalis*, but differing with respect to terminalia; tegmina and wings also noticeably more elongate.

Head in dorsal view with compound eyes prominent, combined width across eyes 6.2 times interocular width; genae barely wider at point of maximum width in frontal view than width across eyes; antennae 2.4 times pronotal length. Pronotum noticeably flaring laterally on metazona; front margin broadly and weakly emarginate on median dorsal line; hind margin obtuse-angulate, the apex somewhat narrowly rounded and the enclosed angle created by extended lateral components of margin about 110°; principal sulcus and two prozonal minor sulci strongly developed; respective lengths of prozona and metazona, along median carina as 1.0 to 1.16; median carina weak anterior to prozonal sulci, obsolete between minor sulci and principal sulcus, prominent on metazona; lateral lobes in lateral view with construction created by two posterior sulci conspicuous; dorsal level of median carina in lateral view decidedly lower at principal sulcus than at extremities, the angle enclosed by prozona and metazona about 165°. Portion of tegmina extending beyond apex of abdomen with respect to total tegminal length as 1.0 to 3.3; wings same length as tegmina when folded. Prosternal spine subconical, slanting slightly posteriorly, of normal length for group. Hind femur extending slightly beyond apex of abdomen, 3.8 times as long as maximum width; hind tibia .86 as long as femur, with 10 external and 11 internal dorsal spines.

Abdomen of average proportions for group; subgenital plate bluntly conical, with vestigial apical tubercle; supra-anal plate acute, subtriangular, maximum width to length as 1.0 to .95, a medio-longitudinal sulcation on basal half bounded laterad by posteriorly converging ridges, a moderately raised shield-shaped area in apical third, lateral margins scarcely raised and dorsolateral prominences absent; furcula represented by very brief knobs slightly more separated than ridges of sulcation; cercus broader than in *occidentalis*, the apex more quadrate and less

[2]In memory of my late friend and teacher, Professor Arthur G. Ruggles, of the University of Minnesota. Long active in organizing and directing grasshopper control campaigns, he would be among the first, if he were living, to urge that a sound foundation regarding the biology of the present grasshopper be obtained as a basis for understanding future outbreaks.

evenly rounded. Aedeagus characterized by fleshy cuplike rim, enclosing three pairs of vertical appendages: lateral appendages arising posteriorly, circling the chamber and terminating on each side in an acute triangular projection; posterior sublateral appendages simple, platelike in lateral view and acute at tips; anterior sublateral appendages cylindrical in dorsal half, with conspicuous subapical corkscrew twist.

Coloration: General coloration reddish brown, blackish and pale areas noticeably contrasting; hind tibia lavender. Head reddish, a black postocular bar circling each eye posteriorly and extending forward with checkered interruptions to fastigium; a median black bar from occiput toward fastigium narrowing anteriorly and briefly interrupted between eyes; face pale gray with irregular brown spots; antennae pale reddish; disk of pronotum brown, darker laterally, some dark and pale longitudinal streaks along anterior margin; shoulders of metazona at junction with lateral lobes pale; lateral lobes pale except for shiny blackish on dorsal half of prozona and central whitish spot adjacent to principal sulcus. Tegmen gray with longitudinal row of conspicuous black and pale flecks; wing faintly tinged with blue, transparent. Front and middle legs pale, irregularly and weakly blotched with brown; hind femur with two diagonal bars of brown on paginal area, these darker on dorsal surface, ventral and mesal surfaces pinkish; hind tibia lavender, paler at base, spines black, apical spurs black-tipped, whitish on basal two-thirds.

Measurements (length in millimeters): Over-all body (to tips of closed tegmina), 27; body, 21; pronotum, 4.2; front femur, 3.5; hind femur, 11.3; tegmen, 20. Maximum width of pronotum (across metazona with lateral lobes in perspective), 4.1 millimeters; minimum width, 3 millimeters.

Female, migratory phase (allotype).—General form as in male, but more robust, larger in size, face less retreating and antennae proportionally shorter. Antennae 1.73 times pronotal length. Length of median carina of prozona to that of metazona as .83 to 1. Hind femur 3.66 times greatest width. Portion of tegmina extending beyond apex of abdomen with respect to total tegminal length as 1.0 to 5.87; cercus bluntly triangular.

Coloration: Slightly darker than male, a purely individual difference.

Measurements (length in millimeters): Overall body, 31; body, 27; pronotum, 5.5; front femur, 3.5; hind femur, 13.2; tegmen, 23.5. Maximum width of pronotum, 5.3; minimum width, 3.9.

Descriptive notes on solitary phase.—The most conspicuous feature of the solitary phase is reduction in the length of tegmina and wings. The extent of reduction may be best expressed as the ratio of hind femoral length to tegminal length. In the solitary phase the tegmen typically varies from about 1.2 to 1.55 times as long as the hind femur, while the ratio is about 1.75 to 2.0 in the migratory phase. Tegmina of solitary males usually extend to the apex of the abdomen or slightly beyond, and occasionally are slightly shorter than the abdomen. Females show more tegminal reduction, this being most noticeable, among those examined,

in specimens from British Columbia and Inyo County, California. The tegmina of some specimens of these series do not exceed the tips of the hind femora, although I have seen no decided brachypterism such as occurs in *M. occidentalis brevipennis* Bruner of western Colorado.

In general, the body size of both sexes is less in the solitary phase, though that is not always true. The following measurements represent size averages and extremes in the two phases (lengths in millimeters):

		Overall body[3]	body	tegmen
migratory phase	♂	26 66 (24 to 29.5)	21.58 (19.5 to 24)	20.45 (18 to 22.3)
solitary phase	♂	20.29 (17 to 23)	19.01 (16.5 to 21)	14.53 (11.5 to 17.5)
migratory phase	♀	30.43 (27.5 to 33.5)	25.72 (23 to 28.5)	23.4 (21 to 25.5)
solitary phase	♀	25.15 (20.6 to 28)	24.04 (20.6 to 28)	17.68 (14 to 21)

In solitary individuals the metazona is proportionately shorter, with respect to the prozona, than in migratory specimens. The metazonal median carina of solitary males averages 1.07 times as long as the prozonal portion of the carina, while the average is 1.17 in migratory males. These averages are 1.14 and 1.26 for solitary and migratory females, respectively. Particularly in males, the posterior angle of the pronotum is frequently less acute in solitary males than in migratory ones. A less definite and less easily measured additional change in the pronotum which is characteristic of the solitary phase is that the median carina tends to be nearly straight or even slightly convex dorsally in solitary specimens, when seen in lateral view, rather than being concave adjacent to the principal sulcus.

As regards color, solitary adults have a tendency toward grayish hues, with poor development of the rich yellowish-red tinge on the pale areas of the pronotum and hind femur which usually characterizes migratory individuals.

Individuals intermediate between solitary and migratory phases.—As is true of Old World species of Acrididae which exhibit both solitary and migratory phases, certain individuals represent a stage between the two phases. In migratory bands occasional individuals occur with tegmina only a little longer than the abdomen. In Oregon I found specimens of this sort at three localities, at each place associated with a swarming band. Three specimens from Milford, Utah, are nearly typical migratory individuals, but to date there has been no confirmation of a migration there. Nevada specimens which I collected in 1949 at the sites of migratory infestations of earlier years were definitely solitary in behavior and abundance. Some of these specimens are variable in wing length, however, showing a weak tendency toward the migratory phase on the part of the populations.

Type.—U. S. National Museum No. 59370.

Paratypes.—Academy of Natural Sciences of Philadelphia; Museum of Comparative Zoology, Cambridge, Mass.; American Museum of Natural History, New York City; California

[3]Same as body length when tegmina do not extend beyond apex of abdomen.

Academy of Sciences, San Francisco, Calif.; British Museum (N. H.), London, England; Bureau of Entomology and Plant Quarantine Laboratory, Bozeman, Mont.; Dominion Entomological Laboratory, Kamloops, B. C.; California State Department of Agriculture, Sacramento, Calif.; Oregon State College, Corvallis, Oreg.; State College of Washington, Pullman, Wash.; Utah State Agricultural College, Logan, Utah; University of California, Berkeley, Calif.; University of Kansas, Lawrence, Kans.; Museum of Zoology, University of Michigan, Ann Arbor, Mich.; University of Minnesota, St. Paul, Minn.; University of Nevada, Reno, Nev.; University of Wyoming, Laramie, Wyo.

Type locality.—Skull Creek Canyon, 20 miles north of Fields, Oreg.

There are 409 paratypes, as enumerated below. Immature specimens of *rugglesi* will be treated in the forthcoming synopsis of the species-group, and they represent several additional localities, none of which, however, adds materially to the distribution. Under the name *occidentalis,* La Rivers (Amer. Midl. Nat. 39:692, 1948) has recorded adults from various other Nevada localities, and, although I have seen some of the material, it is not now before me for paratype designation.

Migratory Phase

Oregon: Skull Creek Canyon, 20 miles north of Fields, June 13, 1949 (A. B. Gurney) (28 ♂, 14 ♀) type and allotype with same data); Fields-Whitehorse Road, June 14, 1949 (Gurney) (11 ♂, 16 ♀); valley 10 miles southeast of Skull Creek (10 miles north of Fields), June 13, 1949 (Gurney) (5 ♂, 4 ♀). *Nevada:* Craine Creek, Humboldt County (just east of Summit Lake Indian Reservation, and about 30 miles west of Quinn River Crossing), July 14, 1948 (W. B. Mabee) (90 ♂, 21 ♀); Gerlach, Washoe County, July 7, 1947 (J. R. Parker) (11 ♂, 8 ♀); Couls Ranch, Lenwood, July 8, 1947 (J. R. Parker) (24 ♂, 15 ♀); 10 miles east of Battle Mountain, on U. S. Highway 40, June 28, 1942 (2 ♂, 8 ♀); 8 miles south of Battle Mountain, June 16, 1941 (J. C. Hamlin) (2 ♂, 1 ♀); Big Smoky Valley, Nye County, July 1939 (G. N. Shogren) (10 ♂, 20 ♀); same, 40 miles north of Tonopah, May 23, 1939 (1 ♂, 5 ♀). *Montana:* Grasshopper Glacier, near Cooke, Park County, 11,000 feet, Aug. 1, 1949 (J. R. Parker, Frank T. Cowan, David G. Hall) (5 ♂, 8 ♀) (apparently the result of an unusual migration or movement by air currents). *Utah:* Desert Range Experiment Station, Milford, Beaver County, June 26, 1945 (V. E. Shelford party) (2 ♂, 1 ♀) (migratory condition not quite typical); Kane County, June 27 1939 (W. W. Henderson) (2 ♂) (no record of migration occurring).

Solitary Phase

British Columbia: Chilcotin, various dates, June 5 to Aug. 16, 1921 (E. R. Buckell) (28 ♂, 28 ♀); Walhachin, July 8, 1927 (E. R. Buckell) (2 ♂, 1 ♀); same, June 21, 1926 (1 ♂). *Idaho:* Big Lost River Range, southeast end, base slopes east of Arco, 5,200 to 5,250 feet, Aug. 12, 1928 (Rehn & Hebard) (1 ♂); Pocatello, Bannock County, Aug. 6, 1910, 4,550 to 5,000 feet (Rehn & Hebard) (1 ♂). *Wyoming:* Rock Springs, 6,250 to 6,500 feet, Aug. 11, 1922 (Rehn) (1 ♂). *Utah:* Cache County, May 14, 1939 (Morris Miller) (1 ♂); Salt Lake Valley, September (2 ♂, 1 ♀); same, Aug. 30 (1 ♂); same, September 1893 (1 ♂, 1 ♀); east side of Pine Valley, Beaver County, Aug. 24, 1926, 6,000 feet (Rehn & Hebard) (1 ♂). *Oregon:* on Highway 95, 37 miles north of McDermitt, Nevada, June 14 1949 (Gurney) (3 ♀); one to 10 miles east of Whitehorse, June 14, 1949 (Gurney) (2 ♂, 1 ♀). *Nevada:* 15 miles north of Quinn River Crossing, three miles south of hotspring on Highway 8A, Humboldt County, June 11, 1949 (Gurney) (1 ♂, 1 ♀); three miles northwest of Battle Mountain, June 10, 1949 (Gurney) (1 ♂); hills beyond east base of Secret Pass, Ruby Mountains, Aug. 7, 1928, 6,100 feet (Rehn & Hebard) (1 ♂); Currie, 27 miles south of Wells, June 9, 1949 (Gurney) (1 ♂); Big Smoky Valley, Nye County, June 2 1949 (Gurney) (8 ♂, 6 ♀); Duckwater, 14 miles north of Currant, Nye County, June 8, 1949 (Gurney) (3 ♂). *California:* Wild Rose Canyon, Panamint Range, Inyo County, 6,500 feet, Sept. 7, 1922 (Rehn) (1 ♀); Baldy, Panamint Range, Inyo County, 9,500 to 10,500 feet, Sept. 7, 1922 (Hebard) (2 ♂, 3 ♀).

Melanoplus rugglesi is most nearly related to *M. occidentalis* (Thos.), from which it may be distinguished by the male terminalia. The cereus of *rugglesi* is broader and the distinctive "corkscrew twist" of the apical portion of the anterior sublateral appendages of the aedeagus differs from the simple apex of these structures in *occidentalis*.

It is clear that *rugglesi* is a characteristic Great Basin species of the *occidentalis* complex. The more eastern *occidentalis occidentalis* extends to Windemere, B. C., western Montana, and central eastern Idaho in the north, while in the southern part of its range it penetrates the Grand Canyon area of northern Arizona. The short-winged *occidentalis brevipennis* of western Colorado intergrades with typical *occidentalis*, but I have seen no convincing evidence of intergradation with *rugglesi*. In southwestern New Mexico and from central Utah southward through much of Arizona *M. cuneatus* Scudder occurs. This has been considered a synonym of *occidentalis occidentalis*, but the types show them to be distinct.